

Apraxia

Neurology, Neuropsychology and Rehabilitation

Jon Marsden

Professor of Rehabilitation

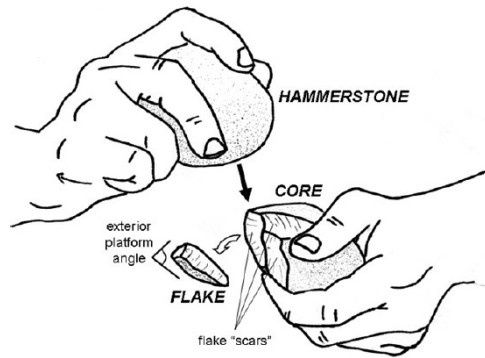
School of Health Professions



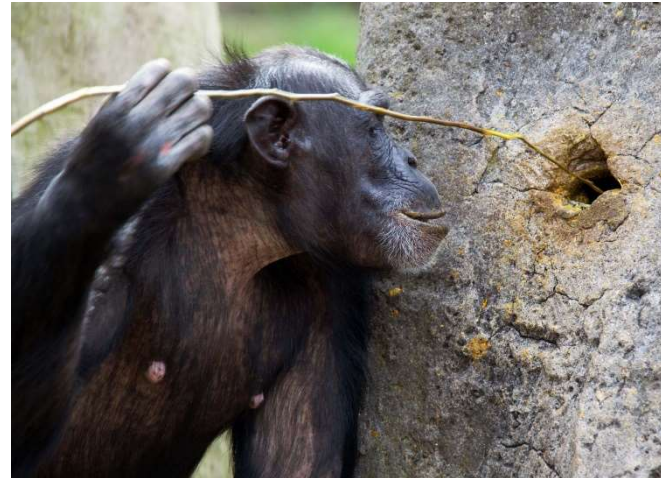
UNIVERSITY OF
PLYMOUTH



Tool Use



D. Stout, T. Chaminade / Neuropsychologia 45 (2007) 1091–1100



Action Steams in the Brain



Apraxia
Definitions, Prevalence and Impact



Ideomotor
Apraxia

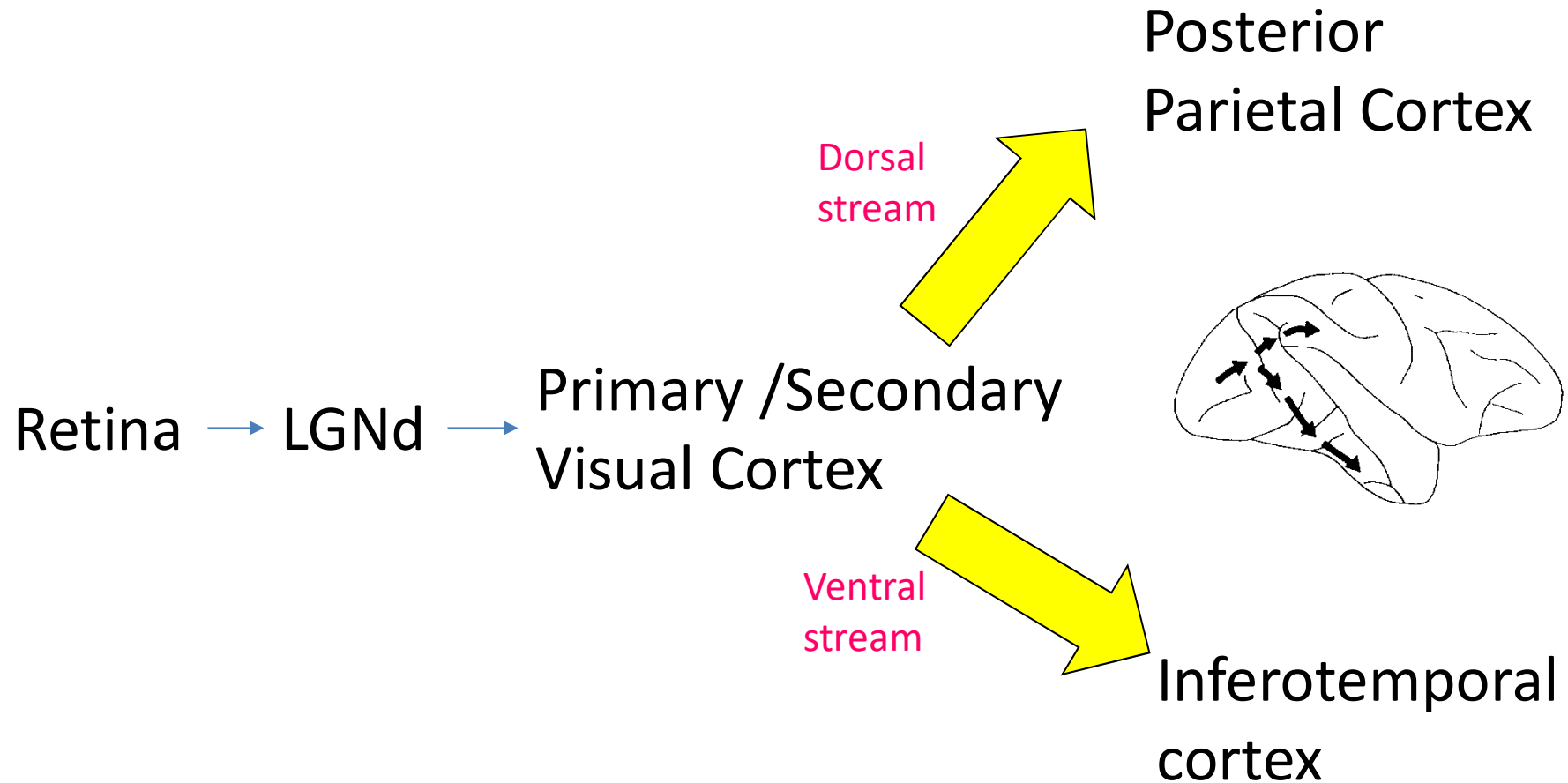
Ideational
Apraxia



Rehabilitation and Recovery
of Apraxia

Action Streams in the Brain

What and How in the Visual System



Visuomotor Control

REACHING

PE-F2

Directional

Coding to objects

In extra-personal

Space

GRASPING

AIP-F5

Transforming visual
intrinsic

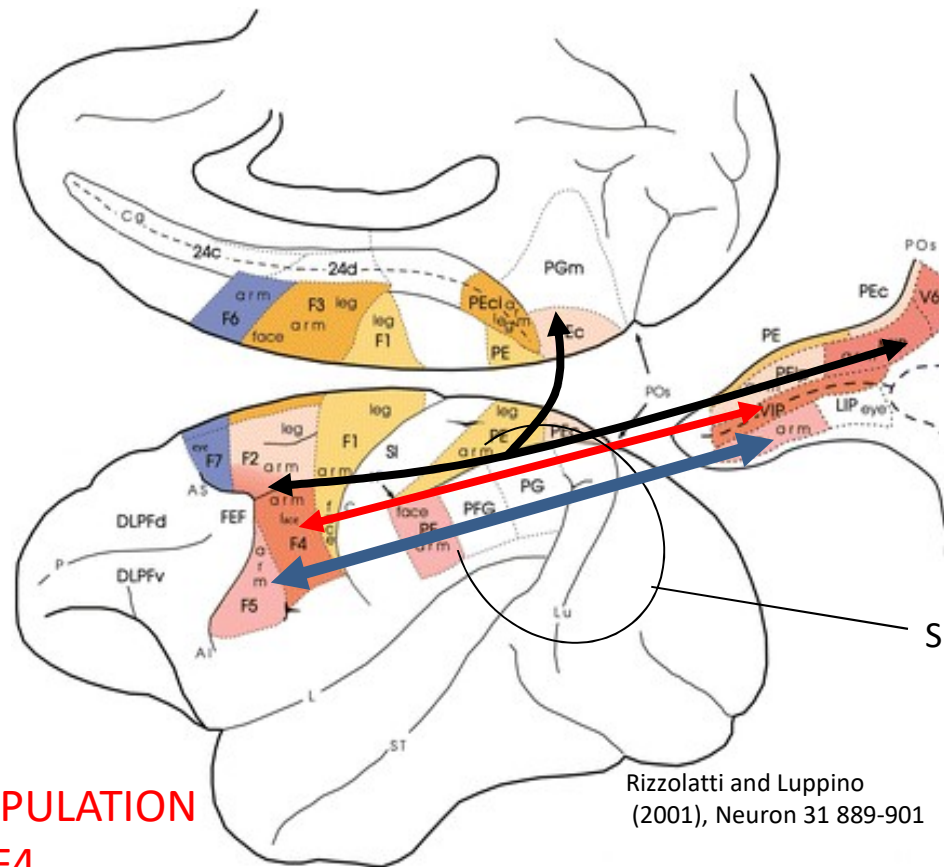
Object attributes into
Motor commands

TOOL MANIPULATION

VIP-F4

Bimodal receptive fields

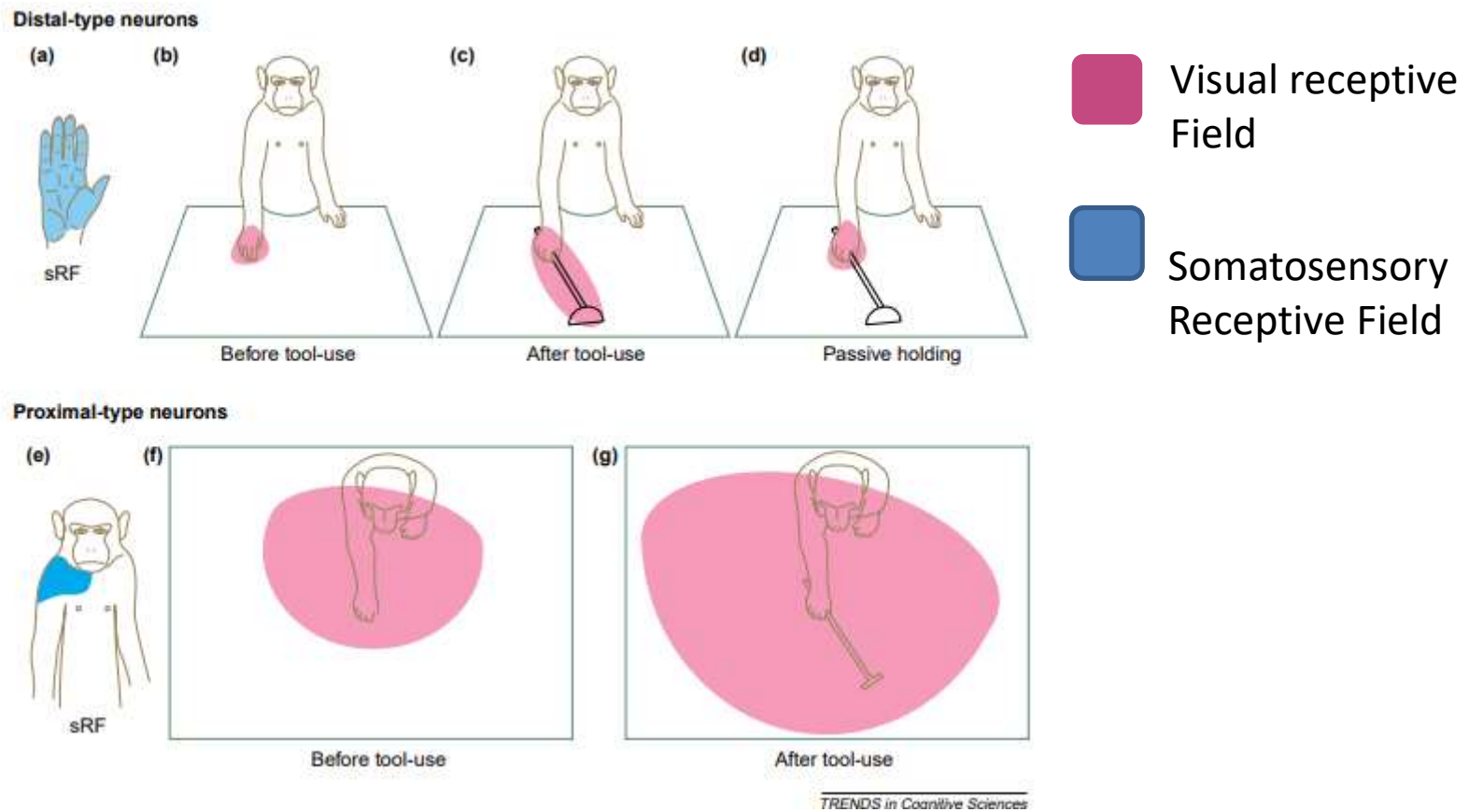
RF altered by tool use



Rizzolatti and Luppino
(2001), Neuron 31 889-901

Sensorimotor Transformation
in Parieto-Frontal Circuits

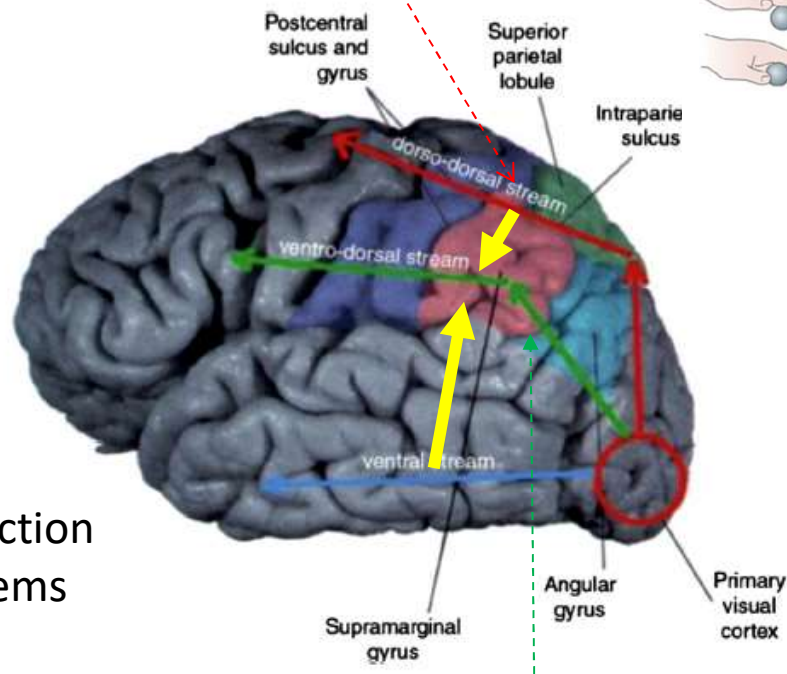
Modification of Body Schema by Tools



Inter-parietal Neurons

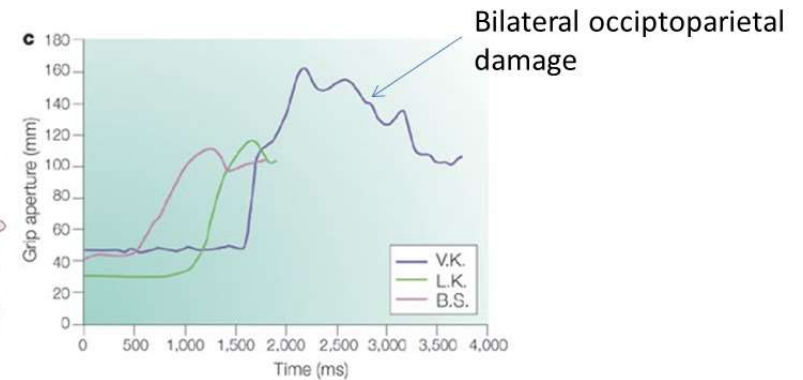
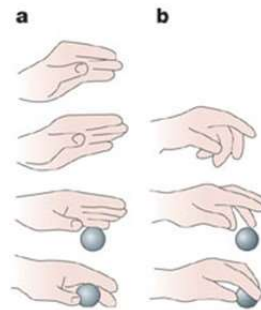
Action Streams in the brain

Bilateral Dorso-dorsal system
 “Grasp” (actions to visual targets)

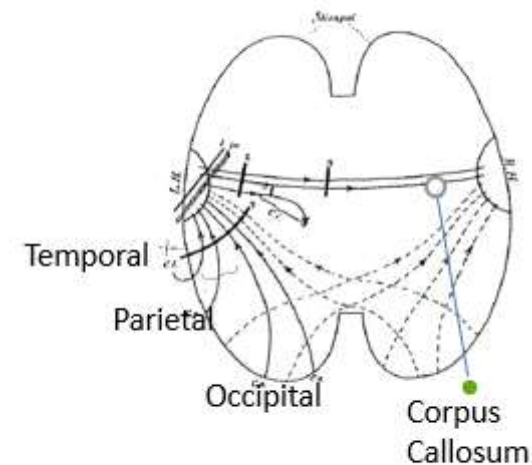


X2 action
 systems
 Vs
 ventral and
 dorsal stream
 Interaction

Left lateralised Ventrodorsal system
 “Use” devoted to skilled functional
 object use



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 Nature Reviews | Neuroscience



Adapted from Liepmann 1920

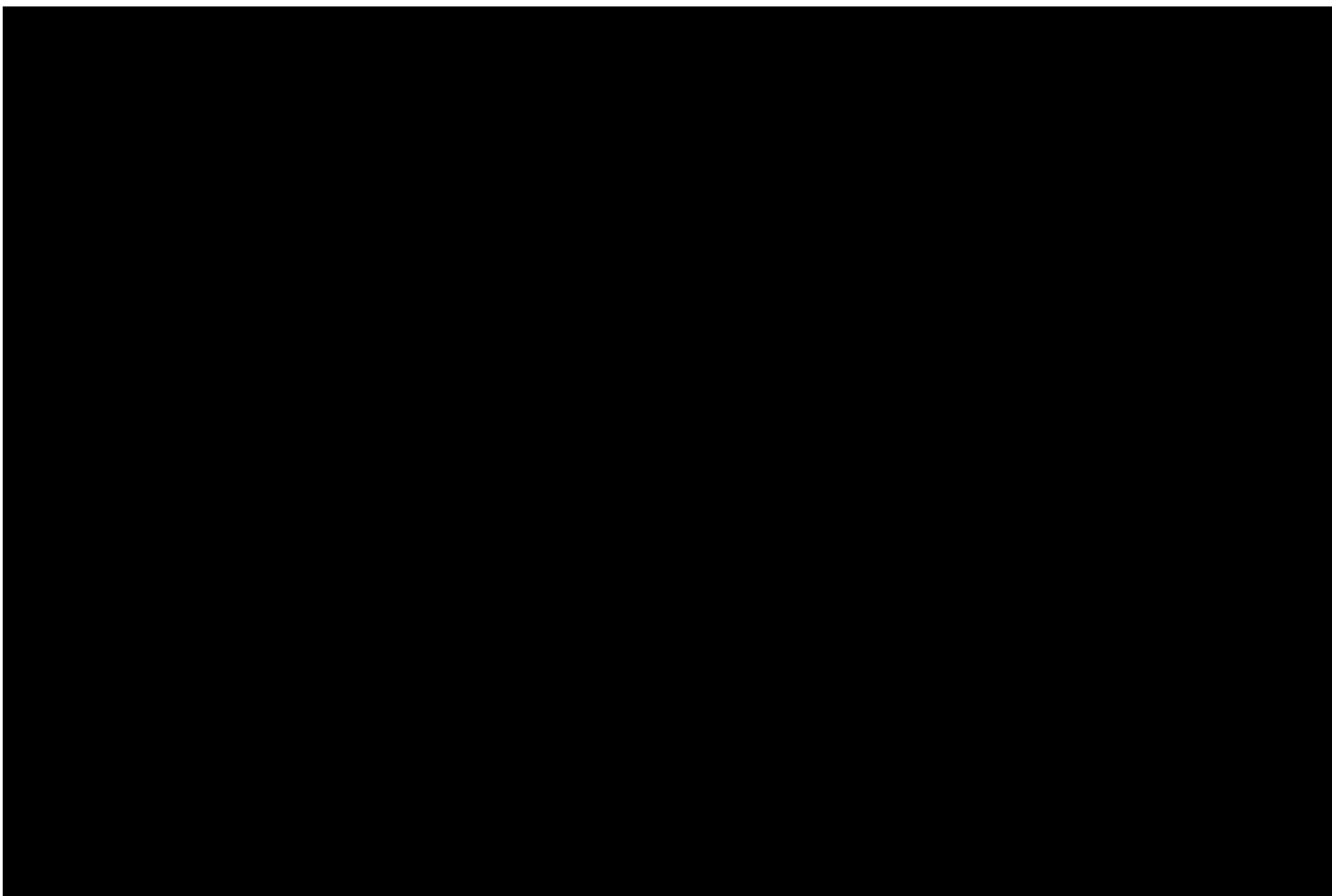
What Is Apraxia

Definitions, Prevalence and Impact

What is Apraxia?

A disorder of skilled movement characterized by:

- an inability to perform purposeful skilled movements
 - an inability to pantomime and/or imitate gestures
 - difficulties in recognizing actions
- Not due to weakness, incoordination, somatosensory loss, or by poor comprehension of or inattention to commands



What is Apraxia?: Prevalence

Stroke

25% all strokes

28-51% of left hemisphere lesions

6% Right hemisphere lesions

Can see with subcortical stroke

Zwinkels et al 2004
Donkervort et al 2000

Multiple Sclerosis

26.3% associated with EDSS / Progressive Forms

Kamm et al 2012

Parkinsons Disease & MSA

27% in PD

Uluduz et al 2010

MSA: apraxia related to cognitive decline

Corticobasal Degeneration

Severe Apraxia

Related to atrophy of pre-motor and parietal Cortex

Burrell et al 2014

Alzheimers Dementia

35% mild, 58% moderate,

98% severe dementia

Edwards et al 1991

What is Apraxia?: Impact

Poor Prognostic Indicator Post Stroke

*Symptoms of Ideomotor Apraxia often less when using an object
(somatosensory feedback and affordances)*

Dexterity problems (eg using/learning
to use utensils) higher in apraxics

Gesture imitation associated with
errors (accuracy; spatiotemporal) in
dexterity tasks

Gesture imitation deficit associated
with carer dependency

Gesture imitation important if aphasic

What is Apraxia?: Impact

“Bodily characteristics typical of the apraxia experience”.

The Subjective View of Apraxia

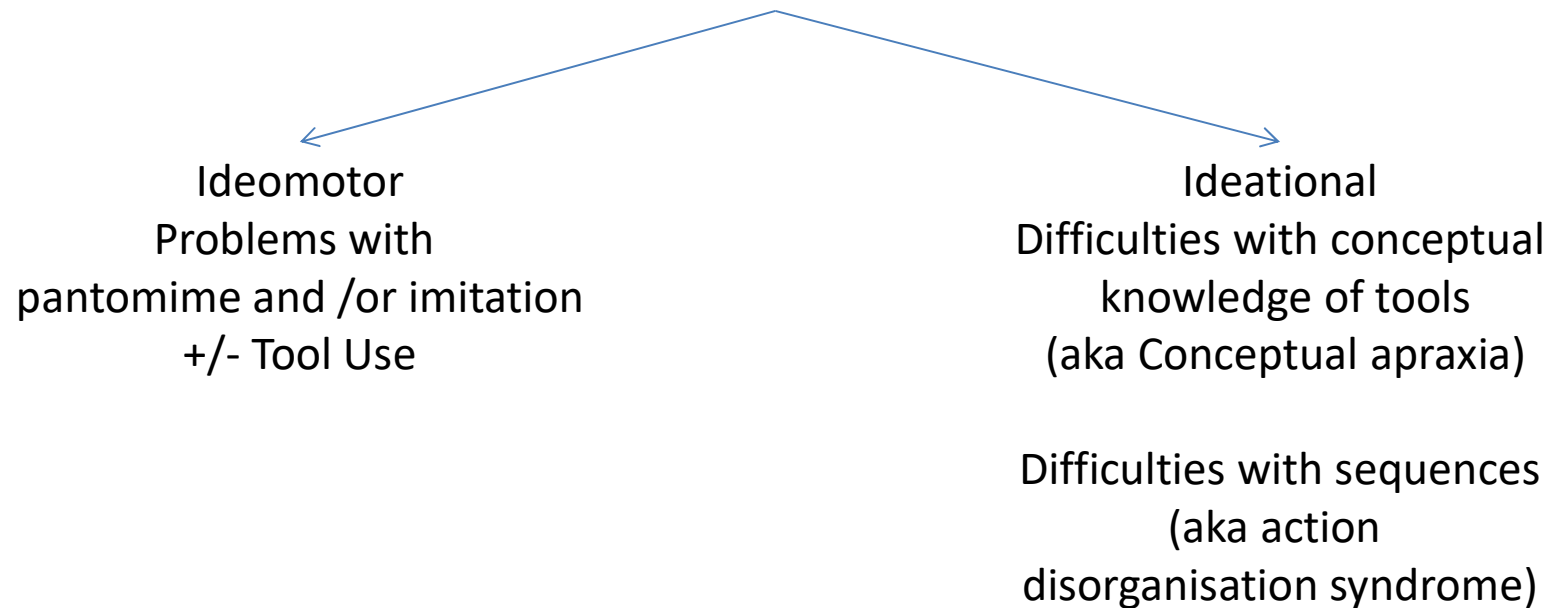
- Gap between intention and bodily action
 - Fragmented awareness in action
 - Peculiar actions and odd bodies
 - Intentionality on the loose
 - Fighting against tools.



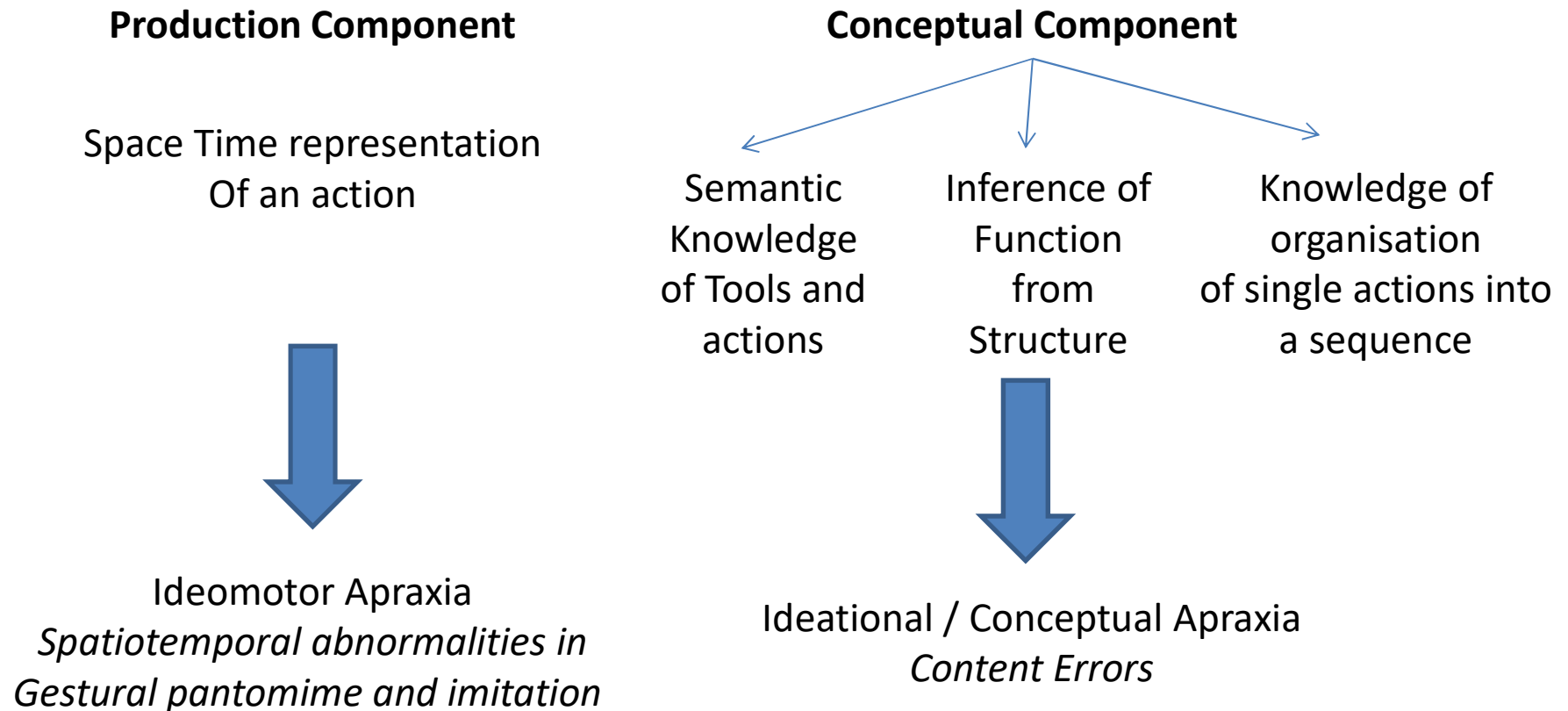
HUGO LIEPMANN



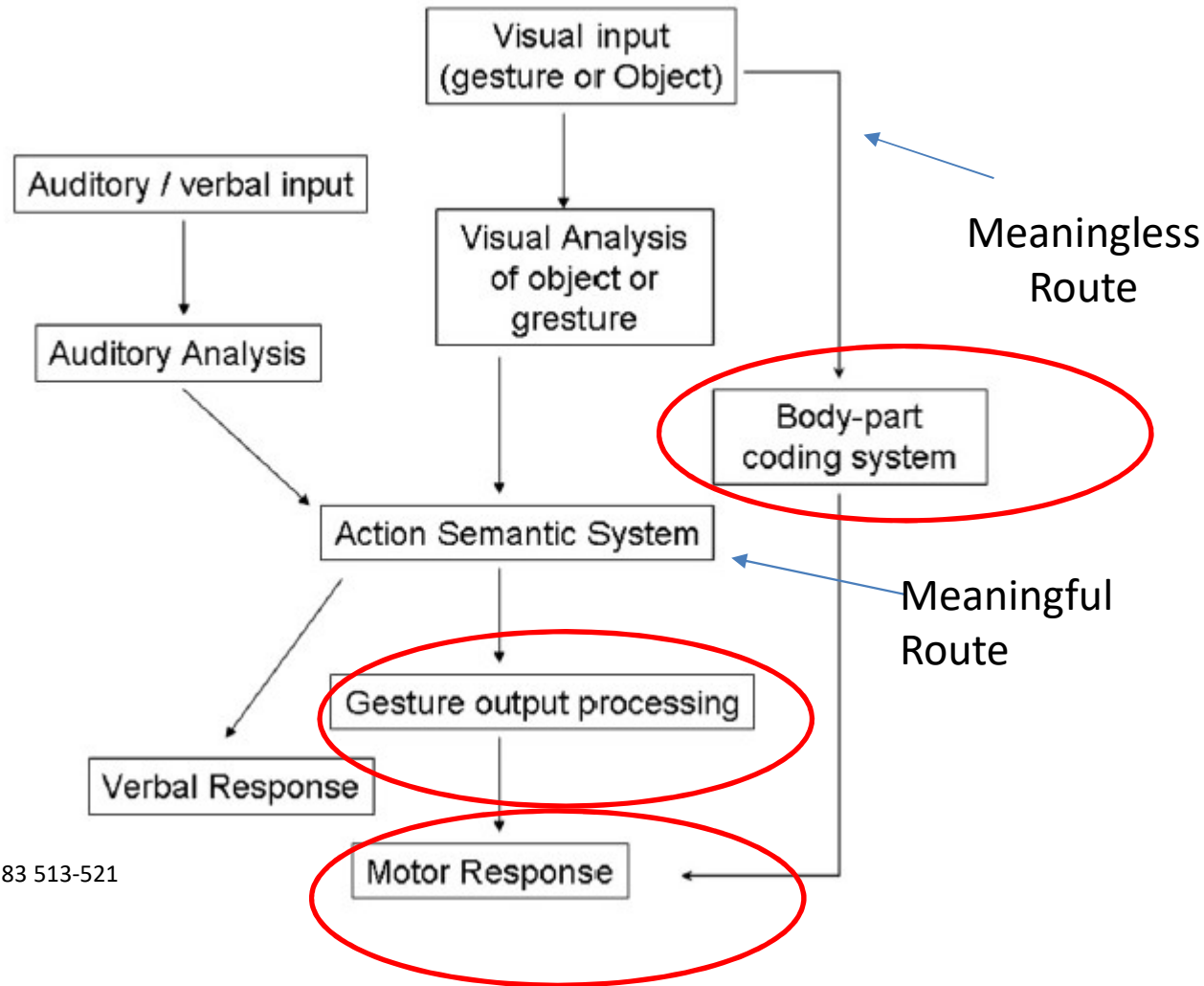
What is Apraxia?



Apraxia



Apraxia: A model of Cognitive Processing



Bikerton et al 2012 JNNP 83 513-521

Stamenova et al 2012

Ideomotor Apraxia:

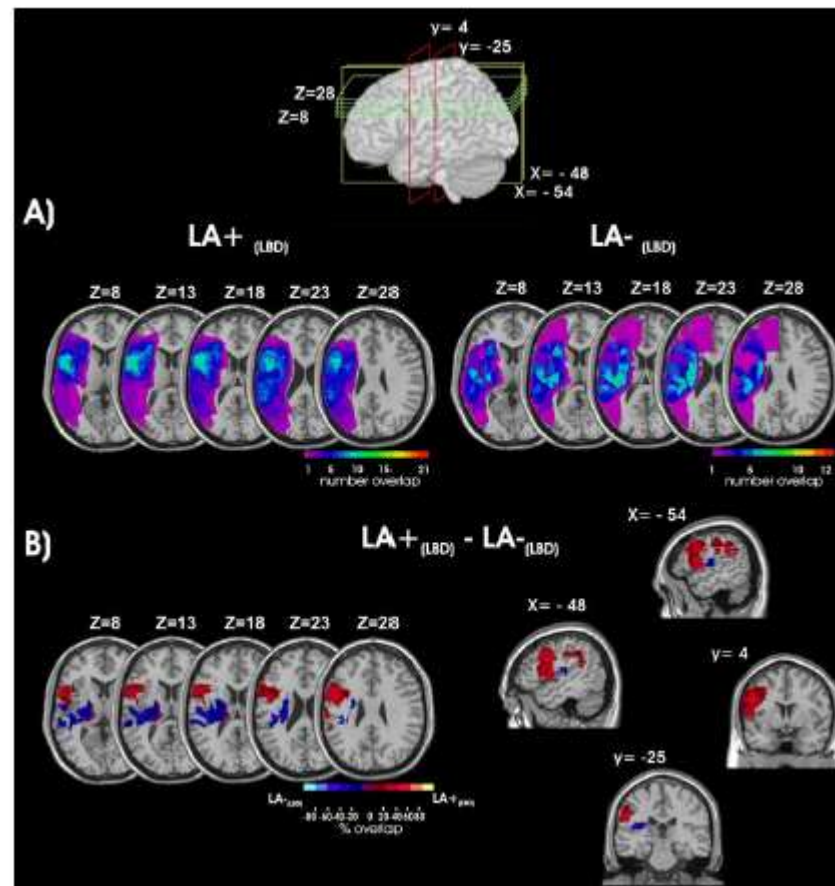
Planning the Right Movement

Ideomotor Apraxia: Lesion Location

LA+ = has limb apraxia LA- Does not have limb apraxia

Areas of Lesion
Overlap

Difference between
LA+ AND LA- groups



Left
Inferior Parietal cortex
Inferior Frontal cortex

Ideomotor Apraxia: Testing

Name patient:
Name examiner:
Diagnosis (incl. lesion localization):

Test date:

Imitation

General instruction: "Seven gestures are demonstrated in a mirror fashion, imitate them as precisely as possible"

	right	left
1. Bring thumb extended on forehead, other fingers point upwards		
2. Wipe dust from shoulder		

Additional instruction: "For the next five gestures, imagine holding a tool or an object in hand, don't use your fingers as a tool"

3. Drink from a glass		
4. Smoke a cigarette		
5. Use a hammer		
6. Use scissors		
7. Use a stamp to postmark		

Pantomime

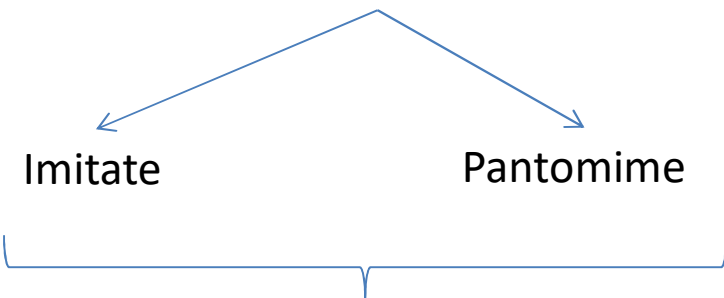
General instruction: "Now gestures are asked. Listen very carefully and perform them as precisely as possible"

8. "Show as if someone is crazy" *		
9. "Make a threatening sign" **		

Additional instruction: "Again, imagine holding a tool or an object in hand, don't use the fingers"

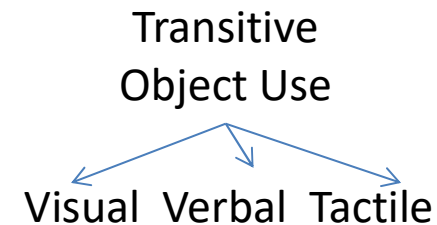
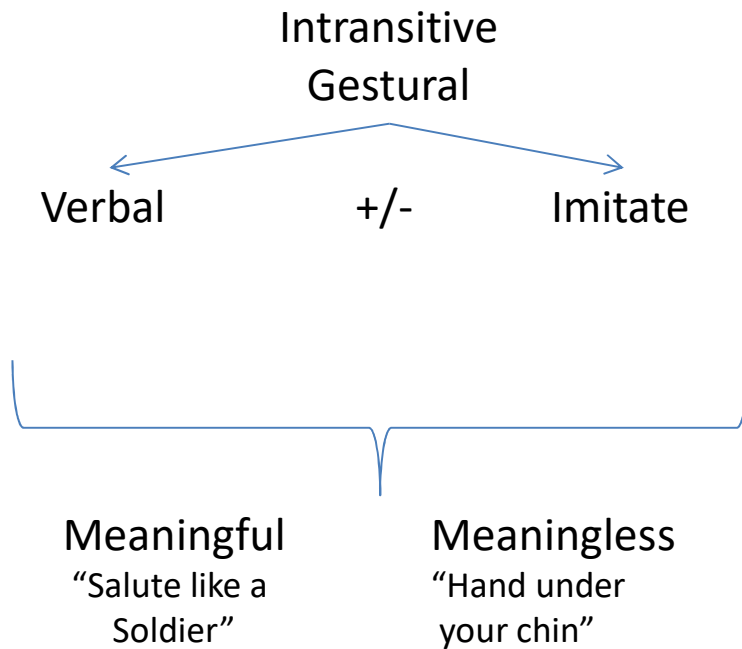
10. "Brush your teeth"		
11. "Comb your hair"		
12. "Use a screwdriver"		
Total Score		

Apraxia Screen of Tulia

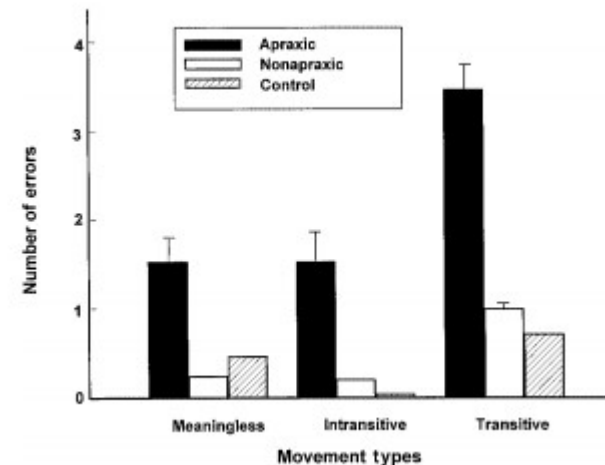


May involve different pathways

Ideomotor Apraxia: Testing



Eg
Show me how you would use a ..
Hammer
Comb
Toothbrush



Ideomotor Apraxia: Errors



Hand Position and Movement Errors

Imitate writing



Healthy Control "Flip a coin"



Patient "Flip a coin"



Hand Position
Error

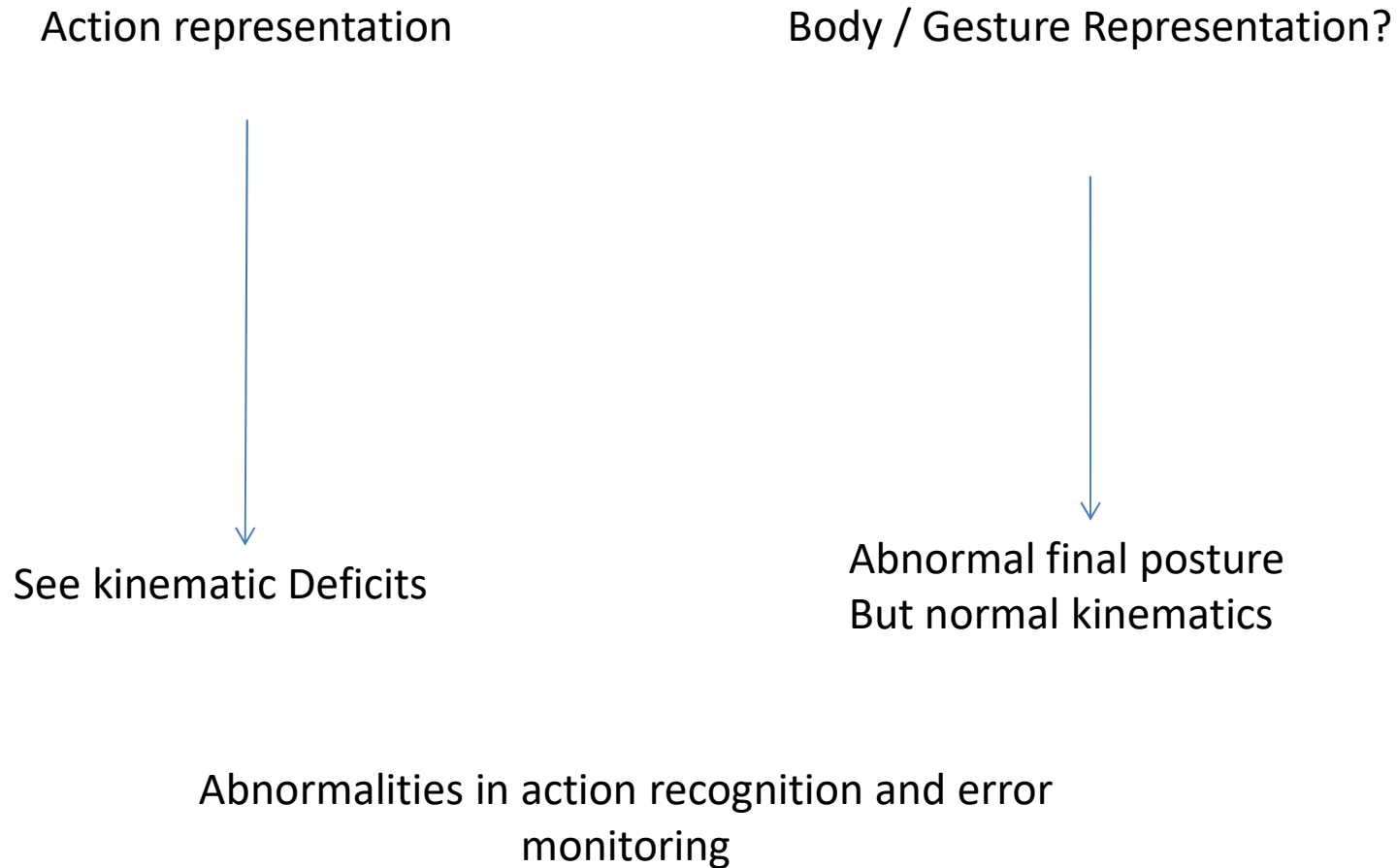


Hand Orientation
Error



Body part
as Object

Production Component: Ideomotor Apraxia



Kinematic Deficits

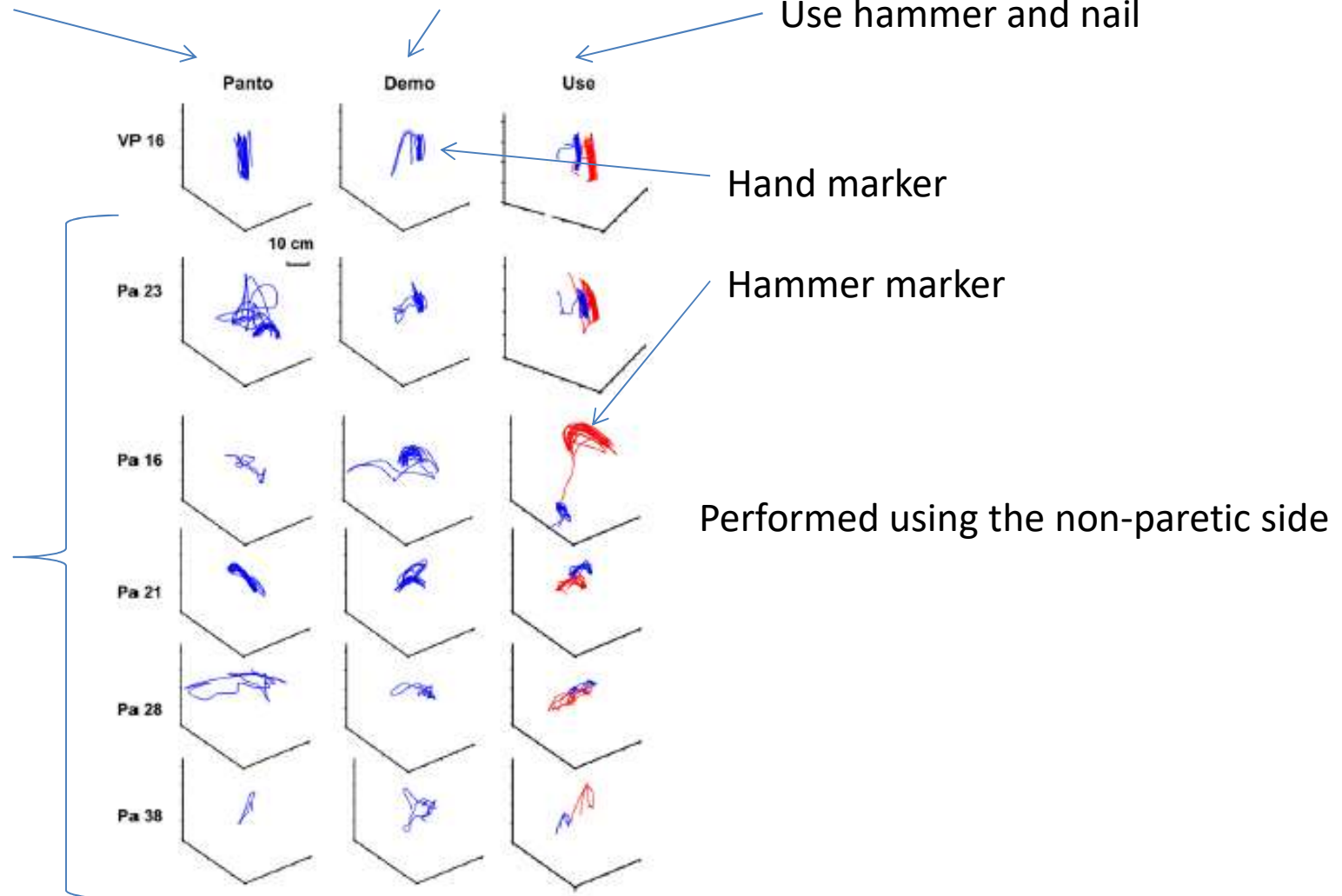
Pantomime

Demo with Hammer

Use hammer and nail

Normal

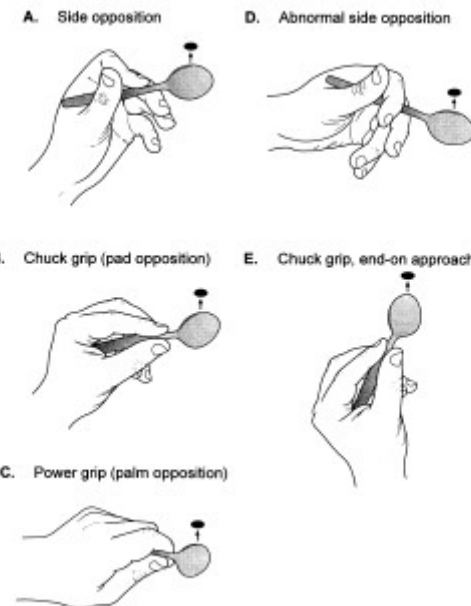
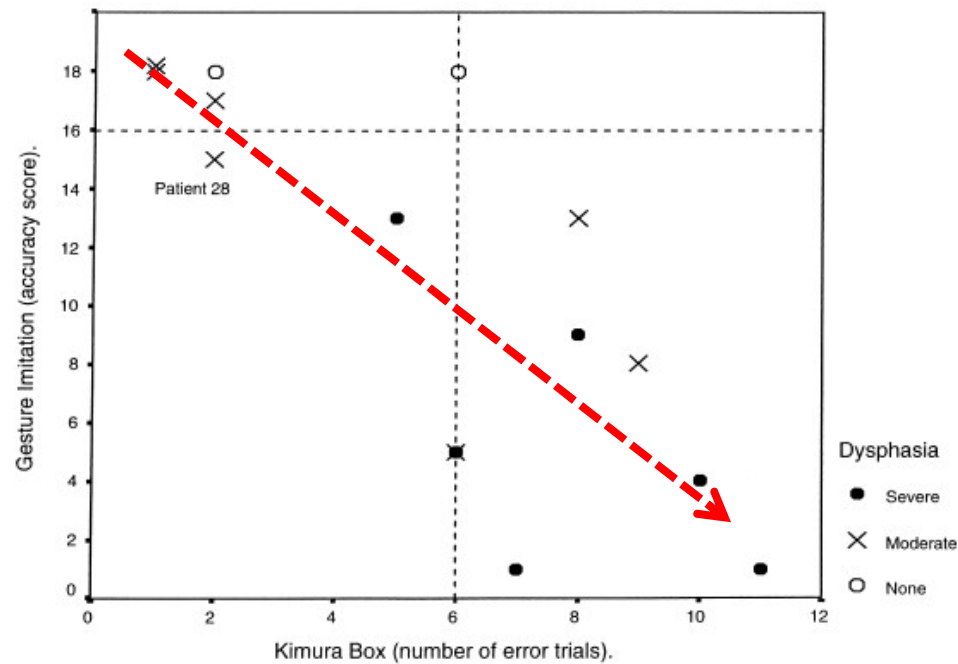
Abnormal



Posture Deficits



Poor hand orientation seen with Kimura Box



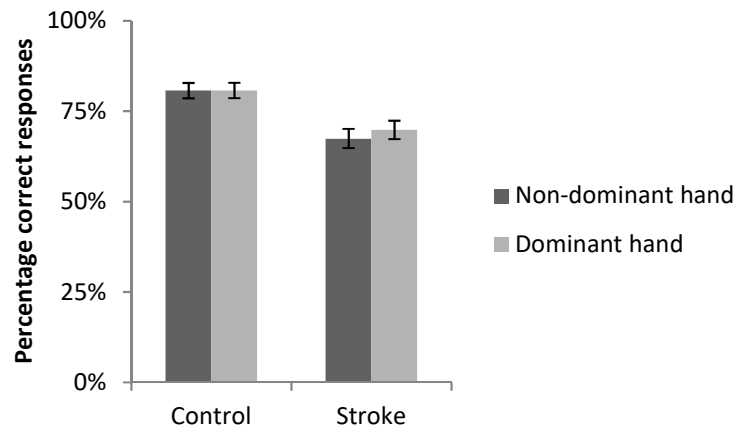
Clumsy posture but more accurate
When object affordances present

Body Representations

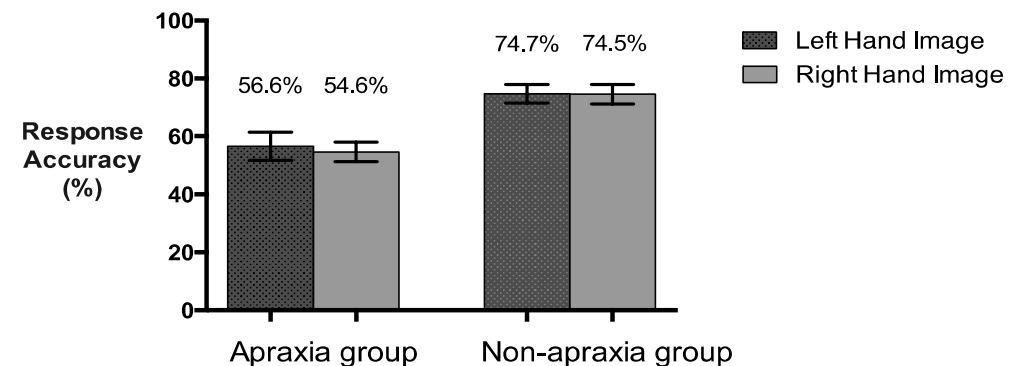
Body Schema



- Lesions centred on Sensori-Motor areas
- Associated with Functional Deficits
- Worse in Apraxics



Amesz et al 2016 Brain Inj 30(8) 999-1004



Lane et al (2019) In preparation

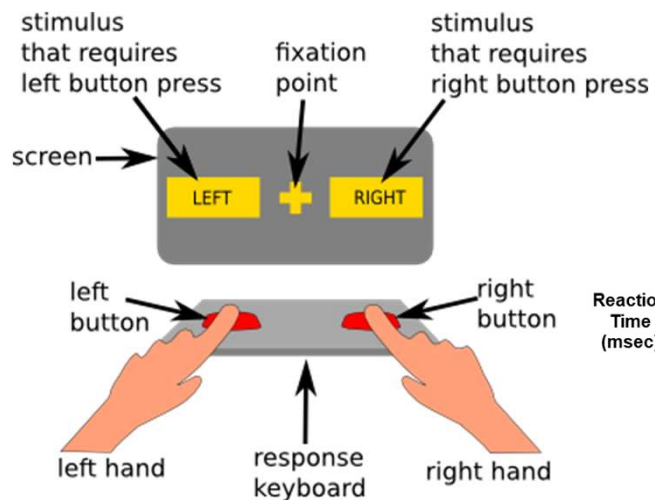
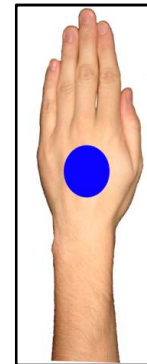
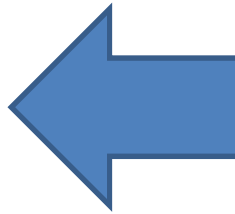
Body Representations

All had defined apraxia

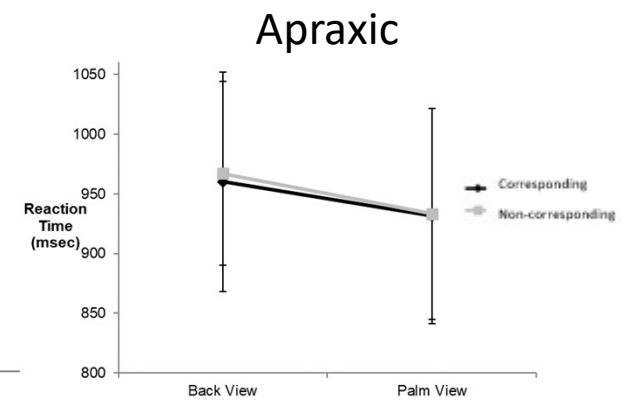
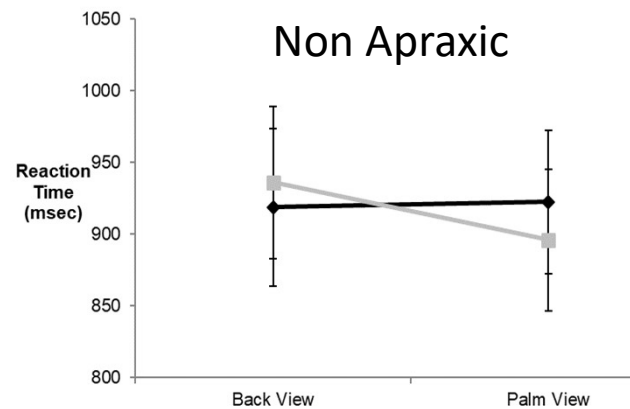
Fronto-parietal Lesions

L>R

Structural Body Description

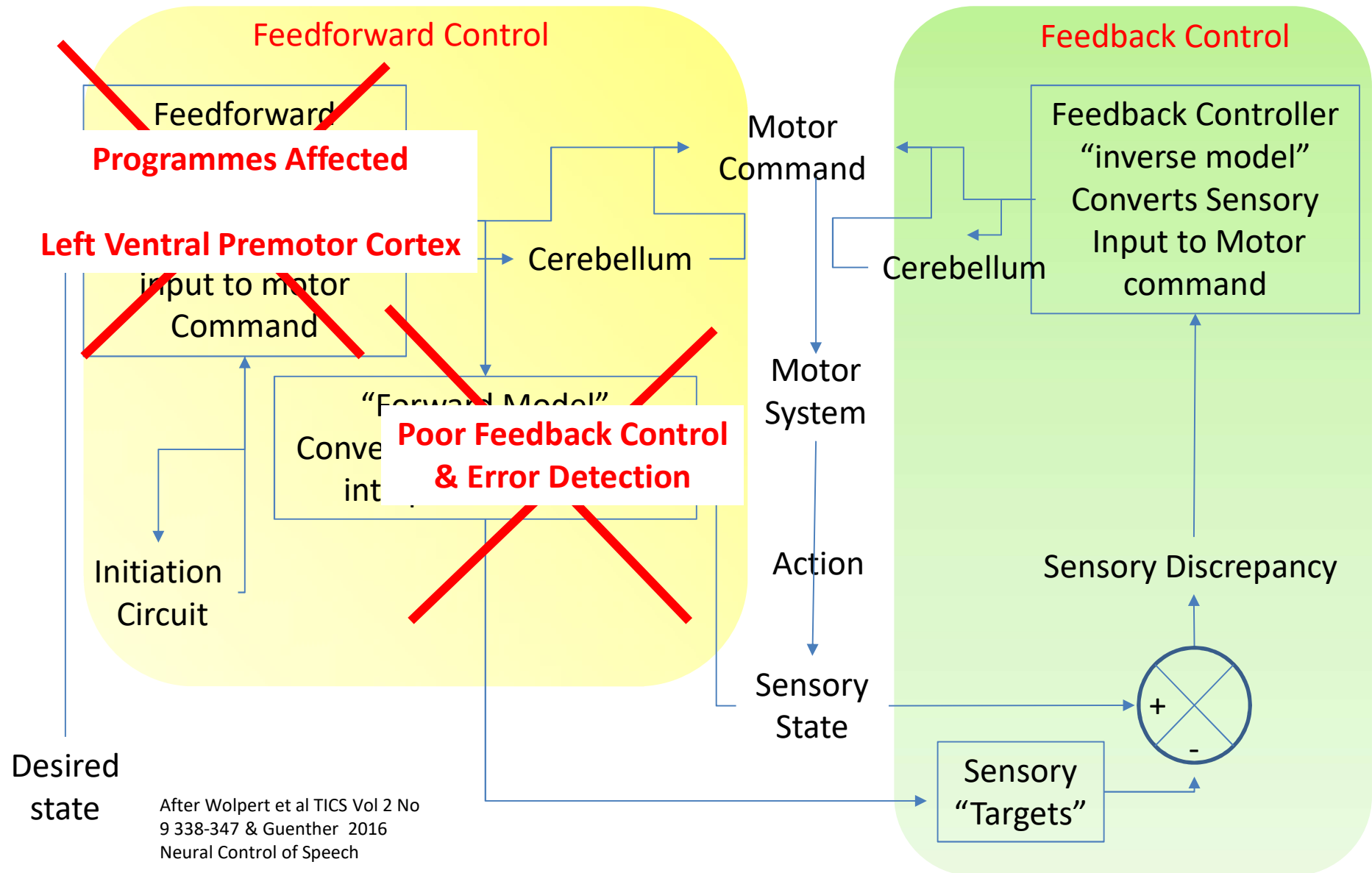


"Implicit Processing of Sidedness"

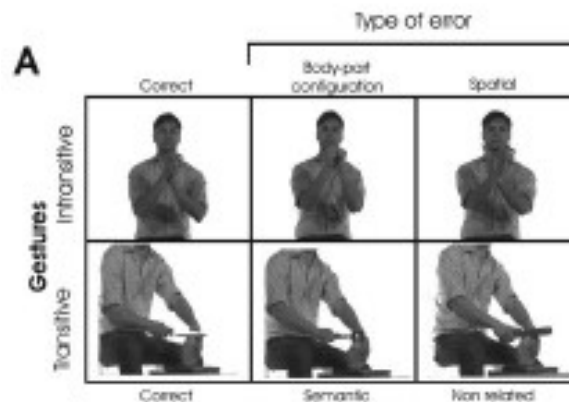
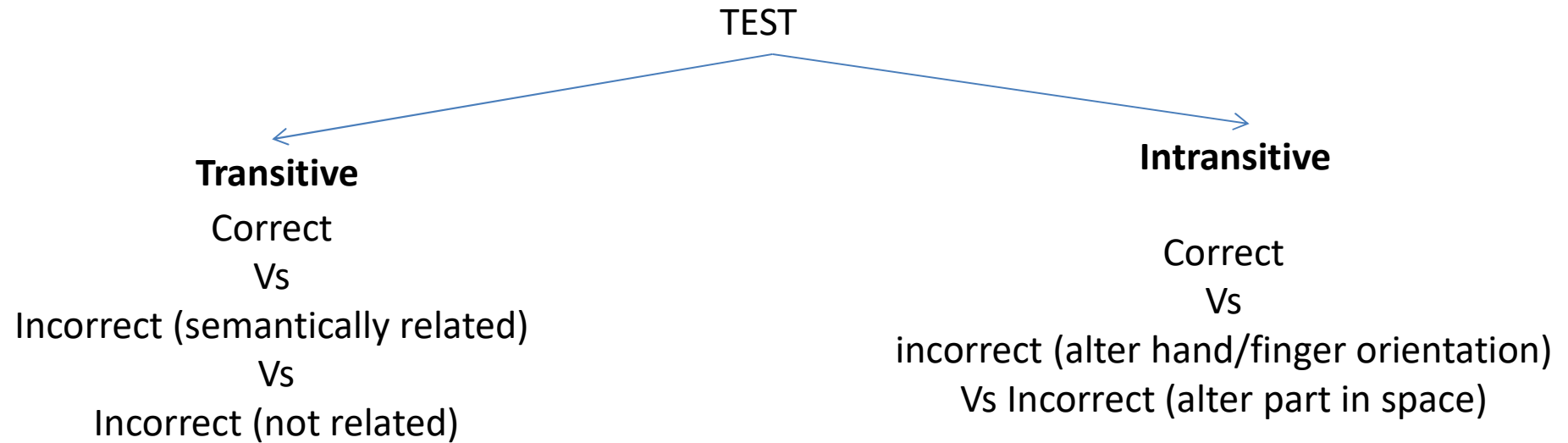


Lane et al (2019) In preparation

A Model of Motor Control

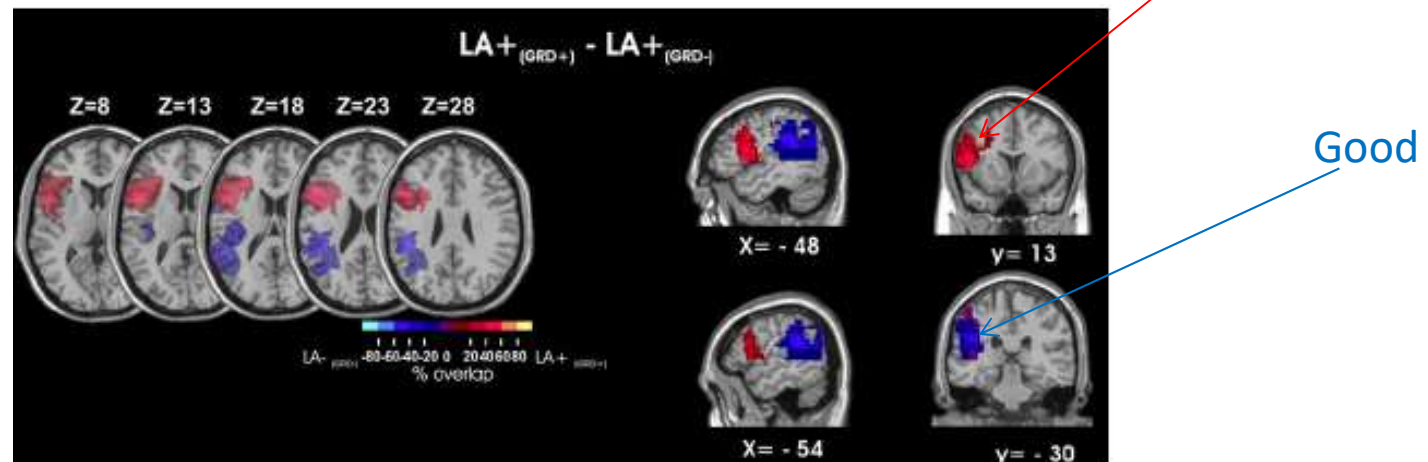


Action Recognition and Error Monitoring



Relationship between Apraxia and Ability to recognize actions

Worse Action Recognition in Apraxia



Pazzaglia et al 2008 J Neuroscience 28 3030

In people with Apraxia

Poor recognition associated with Dorsal premotor / Inferior Frontal Lesions

Better recognition associated with inferior parietal / supramarginal lesions

Representational Vs Dynamic Apraxia

Ideational Apraxia

Choosing the Right Action

Ideational Apraxia: Errors

Sequence errors

- Action Addition
- Action Anticipation
- Step Omission
- Perseveration

Conceptual Errors

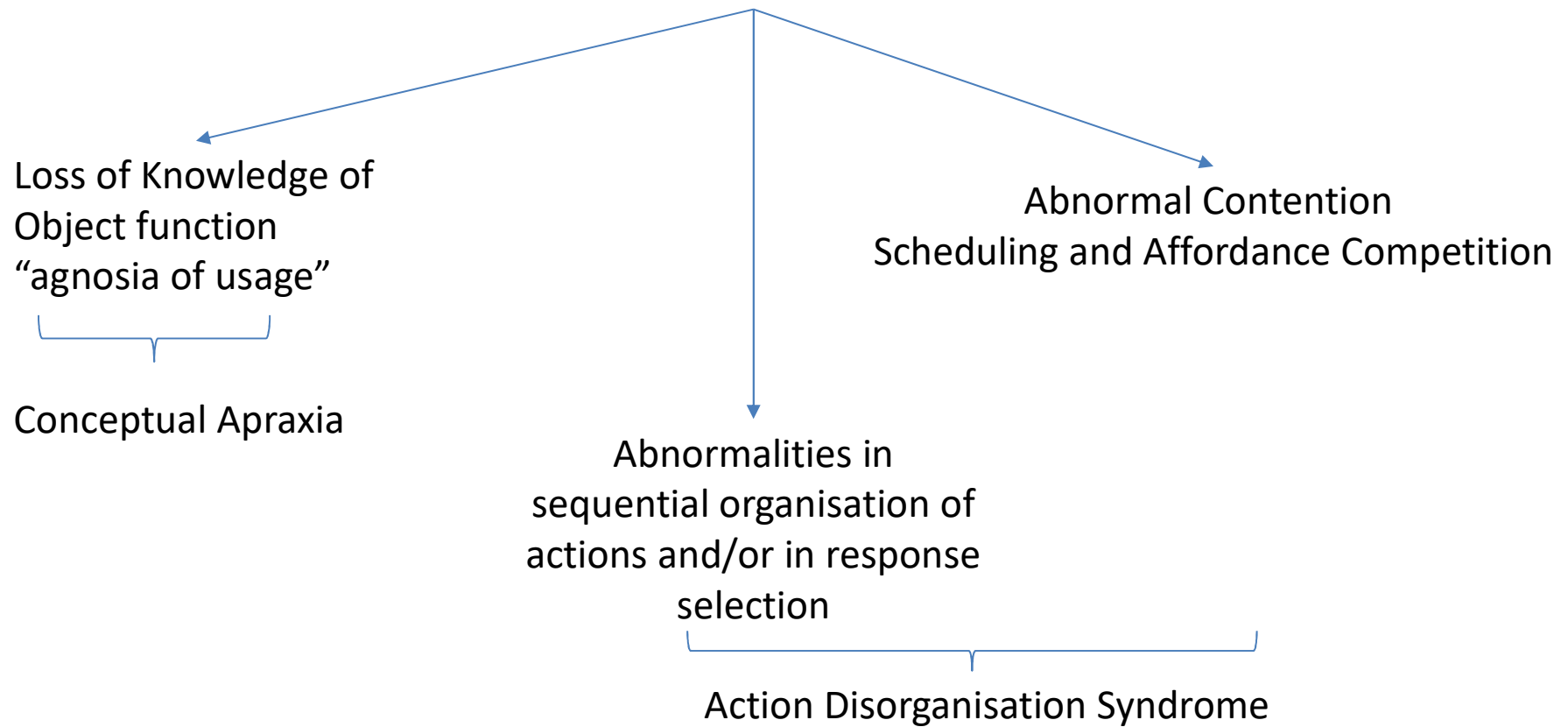
- Misuse
 - misappropriation of object
 - Subordinate action misuse
- Mislocation
 - Action wrong
 - Location of action wrong
- Tool Omission
- Pantomiming
- Perplexity
- Toying

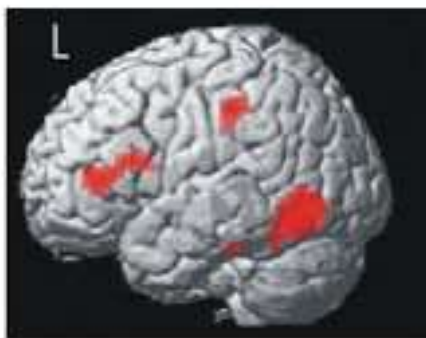


Errors do not correlate with tests of Ideomotor Apraxia
See more errors with complex movements

De Renzi and Lucchelli 1988 Brain 111 1173-1185
Rumiati et al 2001 Cog Neuropsychology 18(7) 617-642

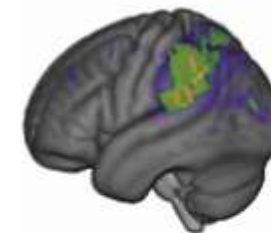
Ideational Apraxia: Theories



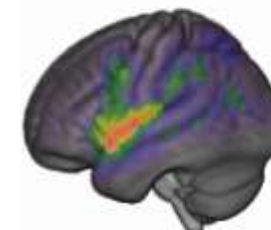


Noppeney (2008) J Physiol (Paris) 102 40-49

Conceptual Apraxia



Tool Use x Tool select ✓



Tool Use ✓ Tool select x

Martin et al Cerebral Cortex
2016 26 3754

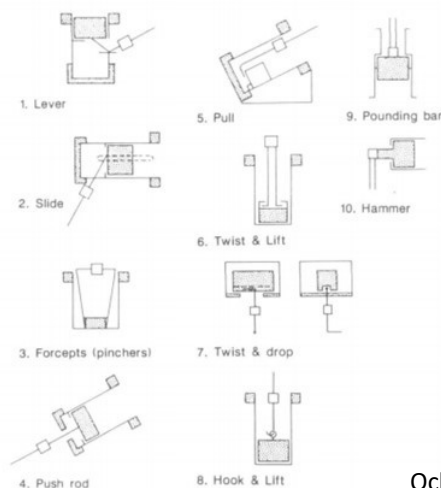
Tool Selection

Match tool to action



Tool Puzzles

Complete mechanical tasks with fingers or tool



Ochipa et al 1992 Brain 115 1061-1071

Stored Knowledge less accessible



Rely more on Object visuo-spatial cues (affordances)

Sequence Errors in Apraxia



Sequential Action-Praxis Test

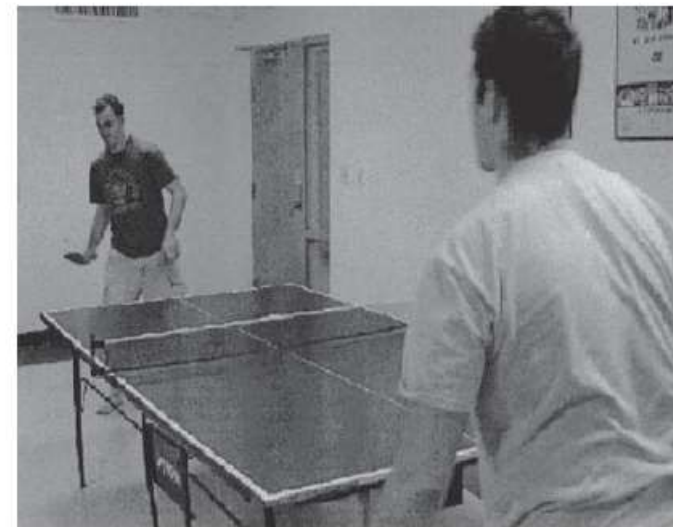


TABLE-TENNIS
PLAYING

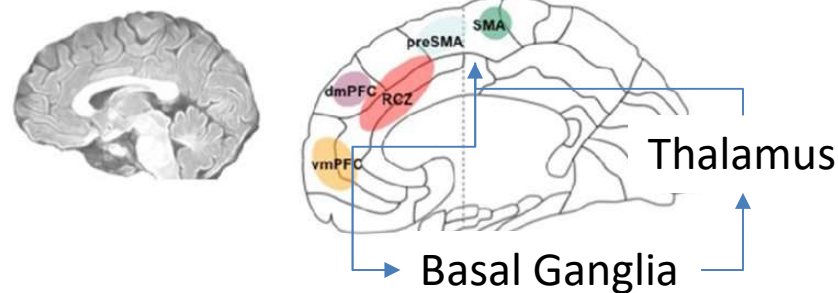
MEN
ARE

Sequential Word-Sentence Test

Deficits Seen in action-praxis test Parkinson's Disease

Sequencing Actions and Movements

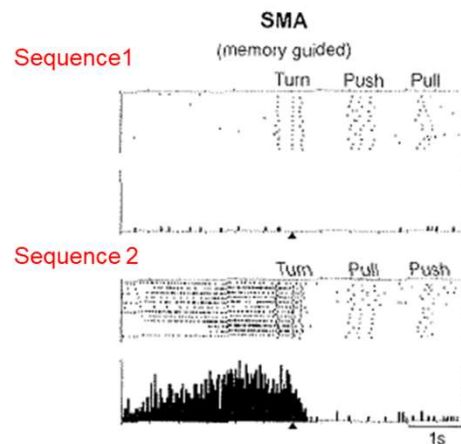
Supplementary Motor Area



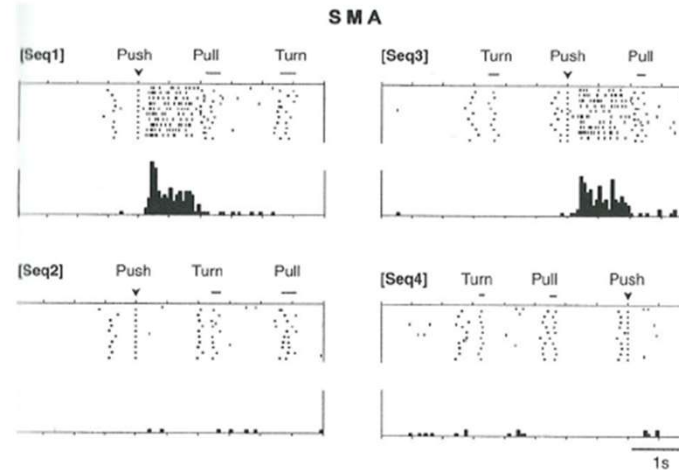
Specify Sequence



Specify the transition between elements



SMA neurone active prior to a
Specific memory guided sequence

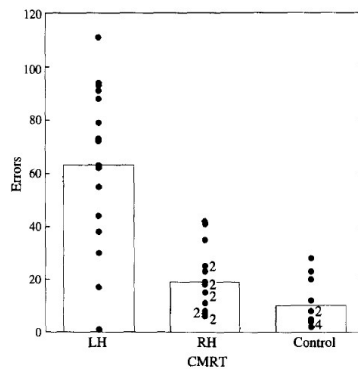
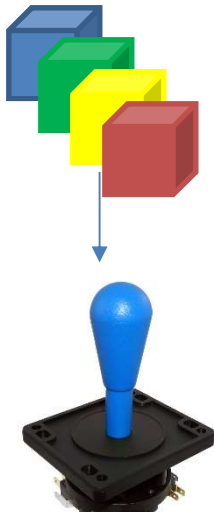


SMA neurone active in the period
Between two specific movements

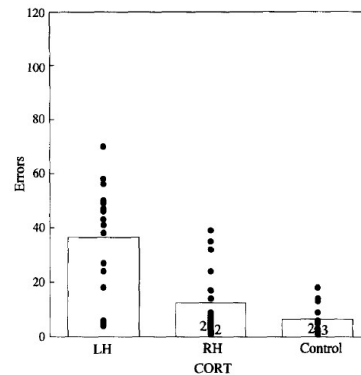
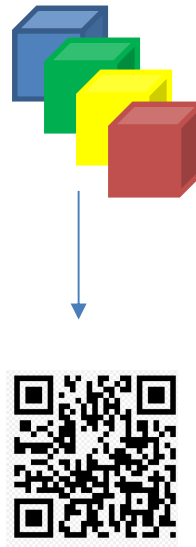
Tanji, J. (1996) In Vision and Movement :
Mechanisms in the cerebral cortex

Sequencing and response selection in Apraxia

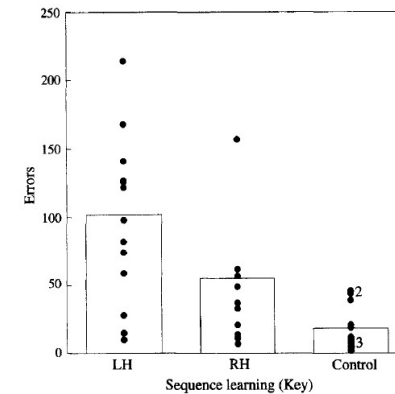
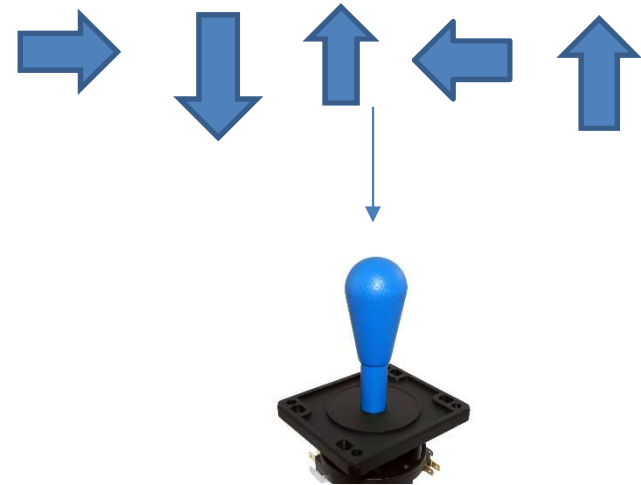
Match cube colour
to movement



Match cube colour
to pattern

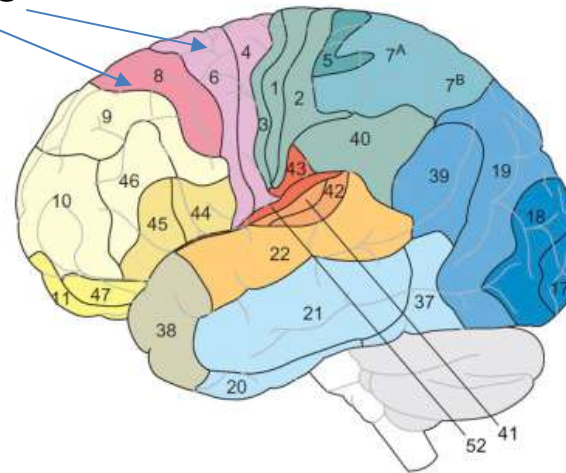


Learn a sequence
through trial and error



Response selection

Premotor
Area 6 and 8

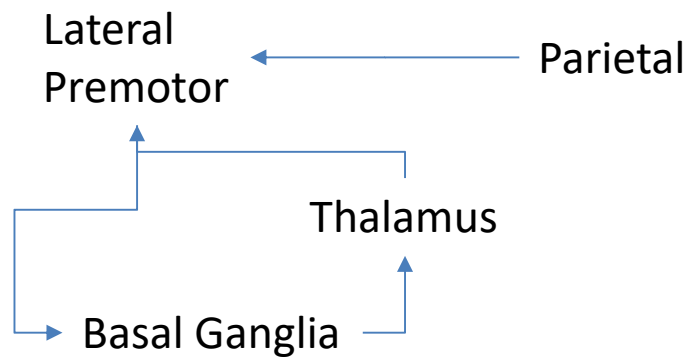


Lateral
Premotor

Parietal

Thalamus

Basal Ganglia

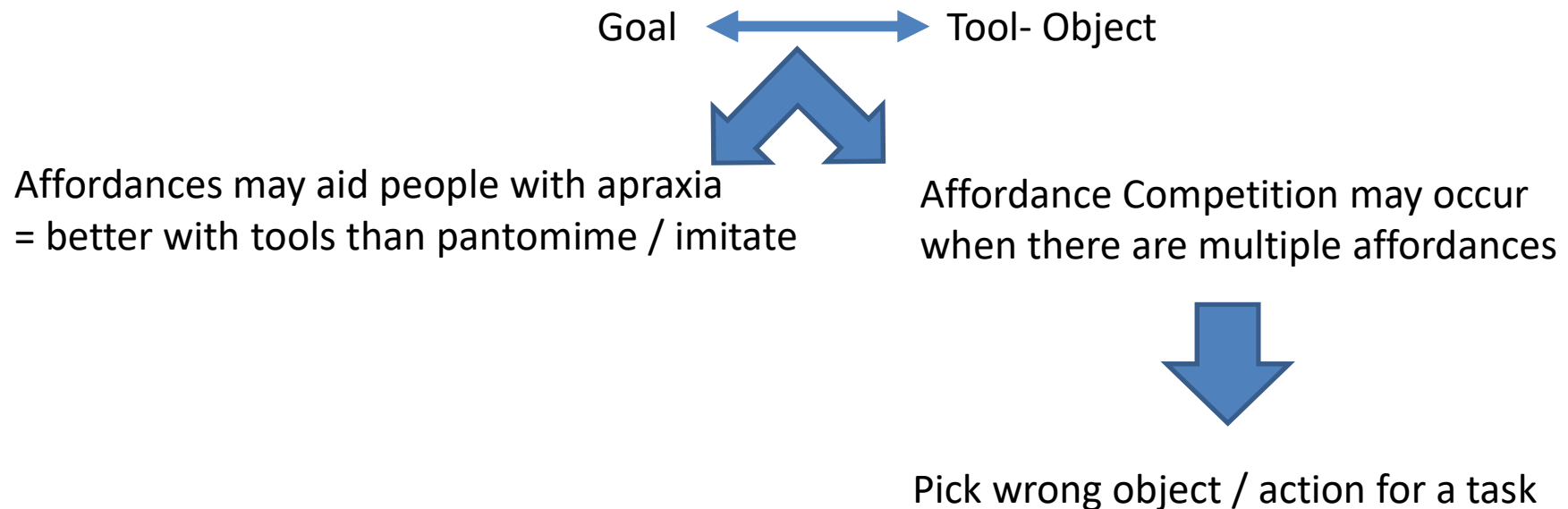


Contention Scheduling and Affordance Competition

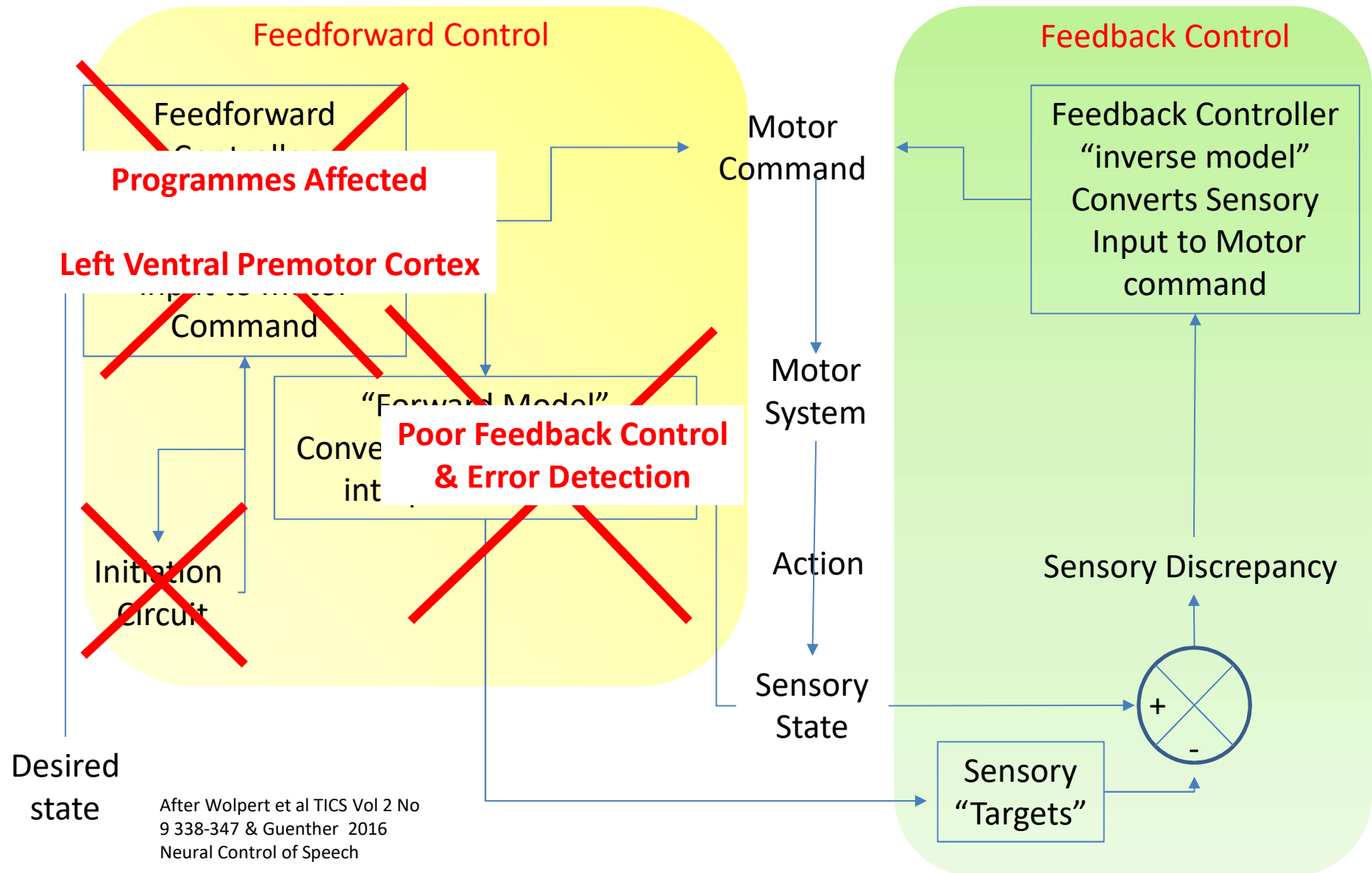
Objects can “afford” **actions** = “graspability”



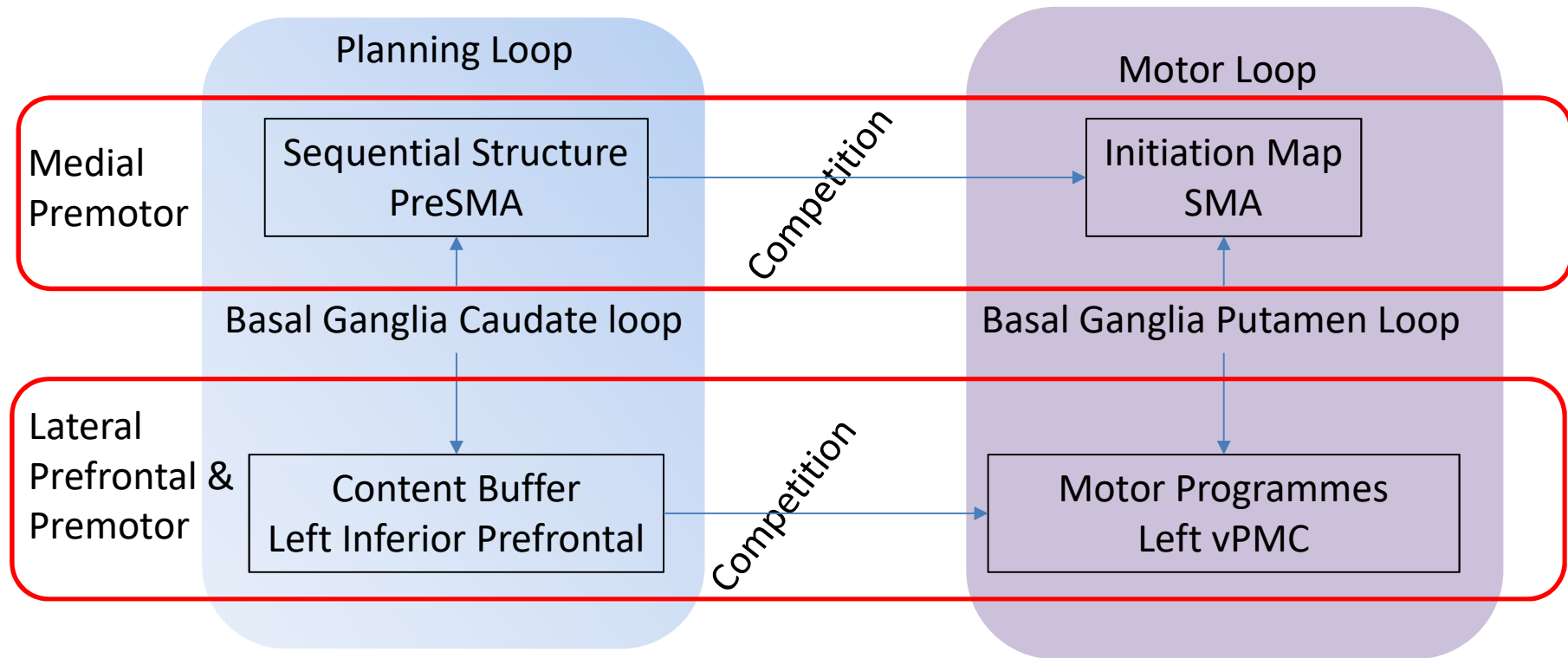
Functional Affordance: Different tools have different abilities to **achieve a Goal**

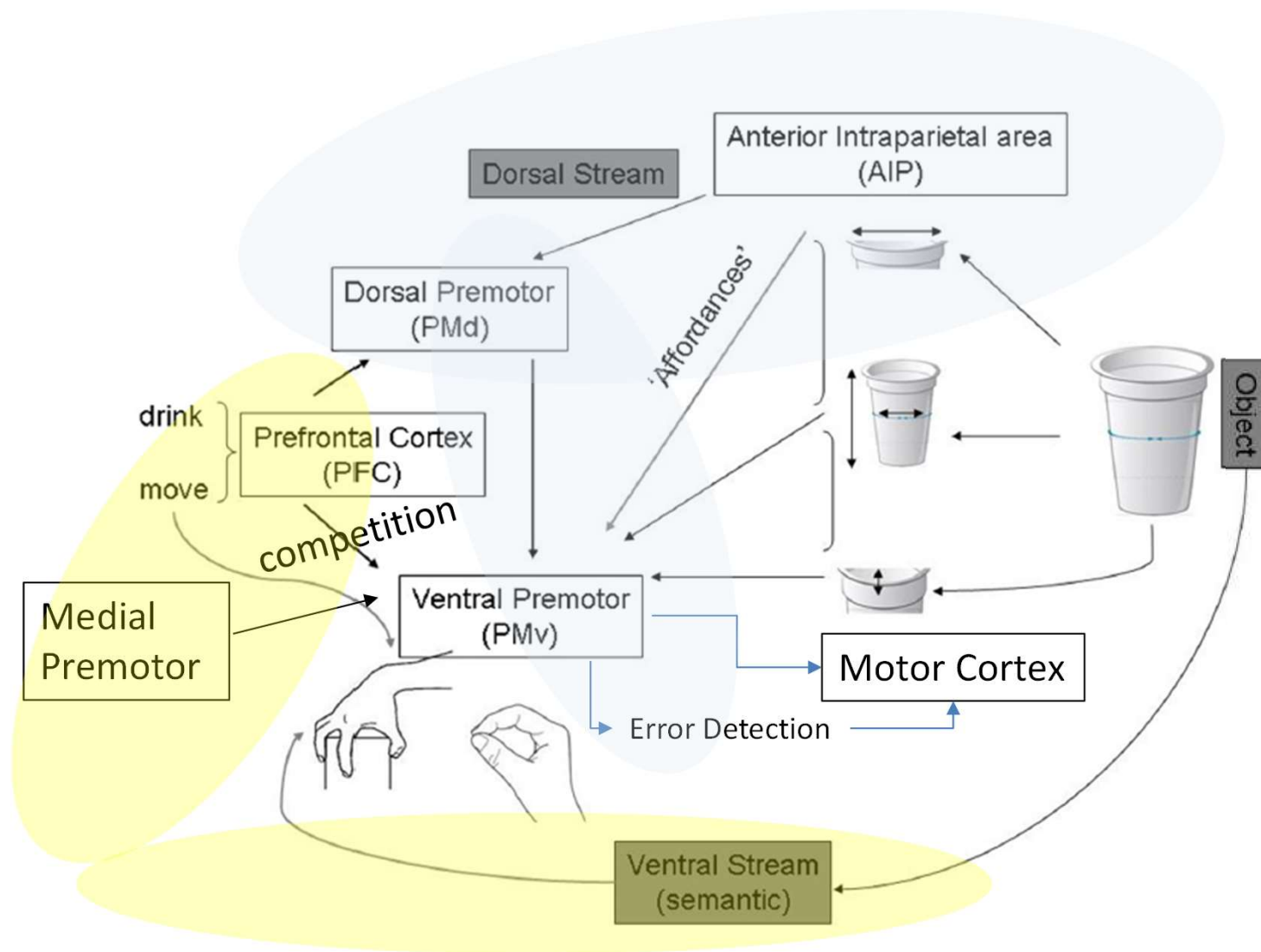


A Model of Motor Control



A Model of Motor Control





Rehabilitation and Recovery of Apraxia

Retraining Pantomime and Imitation

Train

35 sessions 50 mins each x3/week

Transitive-symbolic

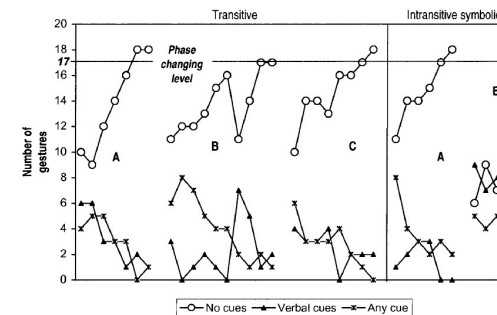
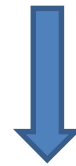
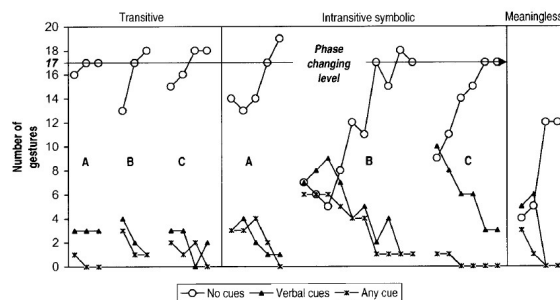
- A Show object and use it (affordances)
- B Show picture using an object--- produce gesture
- C Show picture of an object --- produce gesture

Intransitive-symbolic

- A Context-gesture --- reproduce
- B Context --- gesture
- C New context --- gesture

Intransitive non-symbolic

- Imitate static and dynamic
- Non symbolic intransitive gestures involving distal and proximal components



Improvements with

Apraxia Tests

- Using objects
- Copy intransitive gestures
- Recognizing gestures

Caregiver ADL questionnaire

Task Related Training in Apraxia

12 weeks

3-5 x / week

Focus of relevant functions

Assess activity in terms of errors in
initiation, execution and control

Hierarchical Progression

Instructions

Verbal

Correct environment

Alert patient

Use gestures

Demonstrate task

Show pictures of activity

Write down instructions

Use of objects in correct sequence

Adjust task

Assist

Verbal

Gestures

Pictures

Physical assistance

Take over task

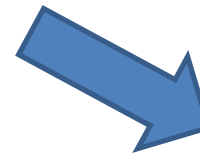
Feedback

None

Verbal

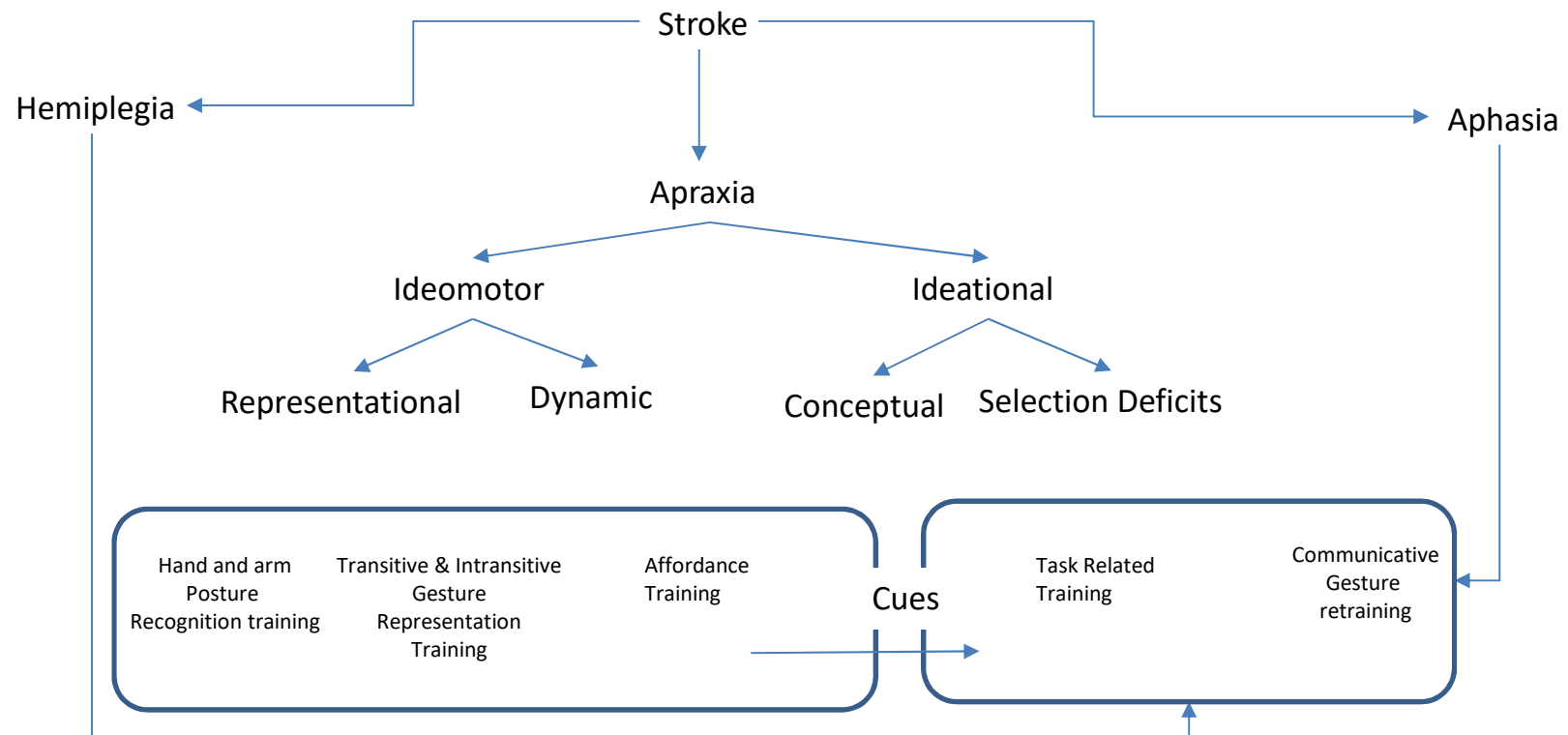
Visual (mirror)

Physical



N=33 No Control
Improvements in ADL and
Apraxia Tests

Towards a theory driven treatment algorithm for Apraxia

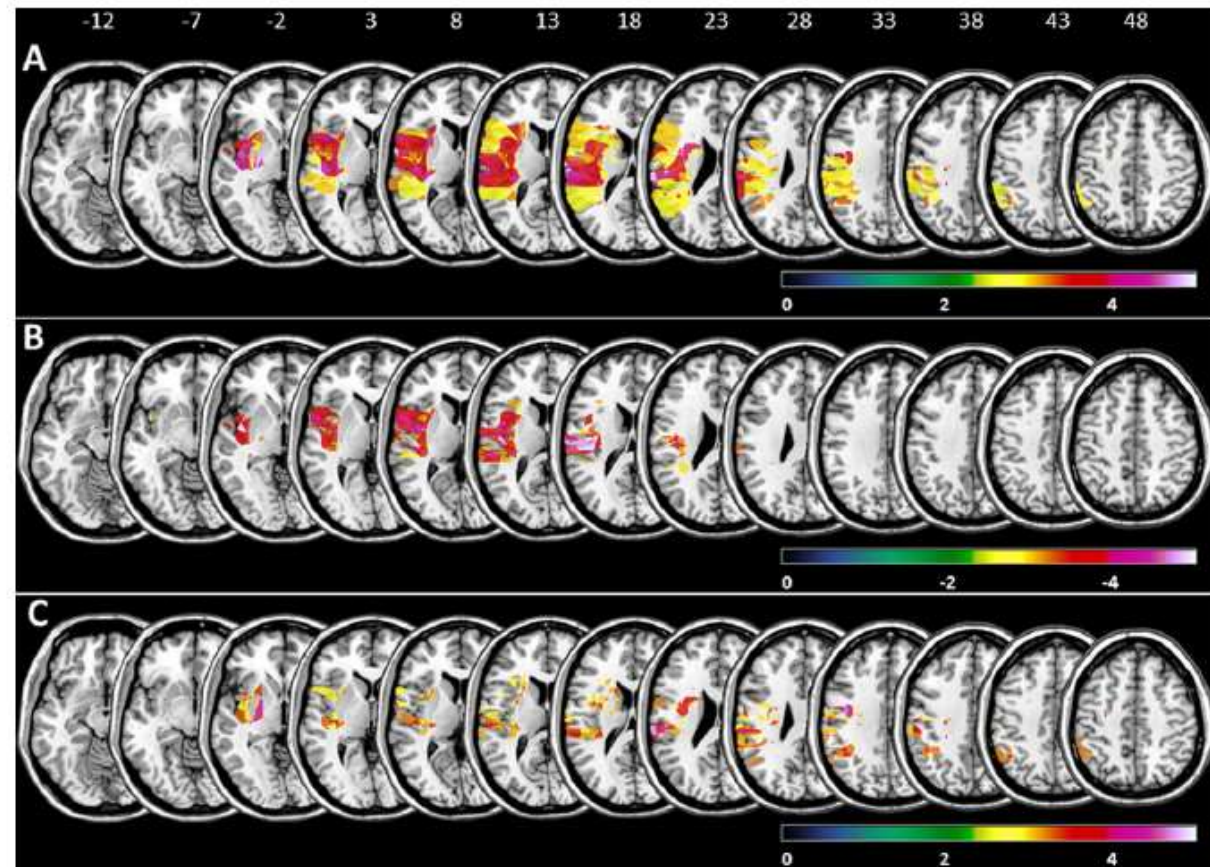


Changes in representation over time?

Lesions associated with initial apraxia

Lesions associated with recovery of apraxia

Lesions associated with persistent apraxia



- Left insula associated with remission.
- Inferior parietal Lobe and superior longitudinal fasciculus associated with persistent deficits

Conclusion

- Fronto-parietal Circuits interact with Subcortical areas particularly the Basal Ganglia to control reaching, grasping and tool use
 - Many dissociations can occur in apraxia
- Impairment based and task based training may lead to improvement in Apraxia
- Action Representation/Recognition Systems may be capable of adaptation post lesion